



Cooperative Microsystems

Dr. Joseph Pancrazio

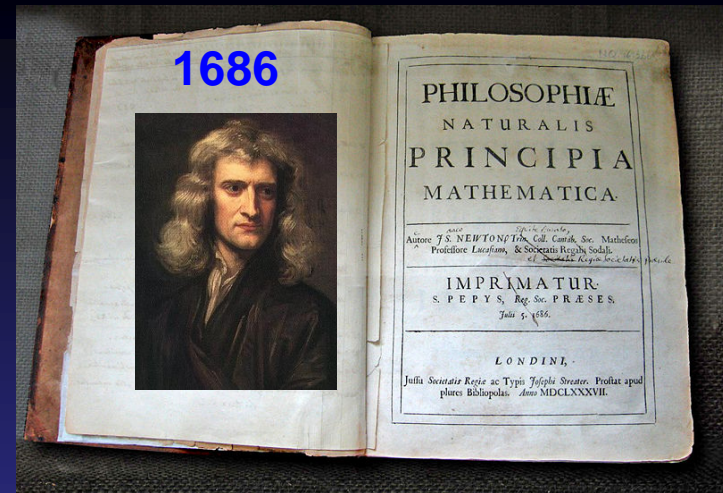
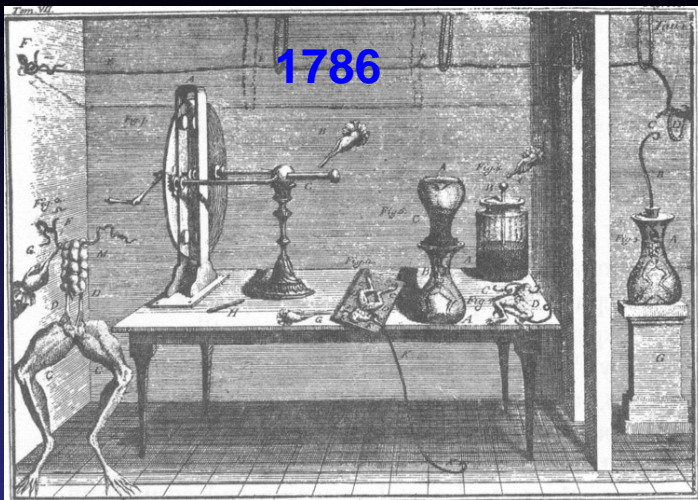
Program Director,
Extramural Research Program,
National Institute of Neurological Disorders
and Stroke / National Institutes of Health

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Cooperative Microsystems and Neural Interfaces



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Program Director
March 4, 2009

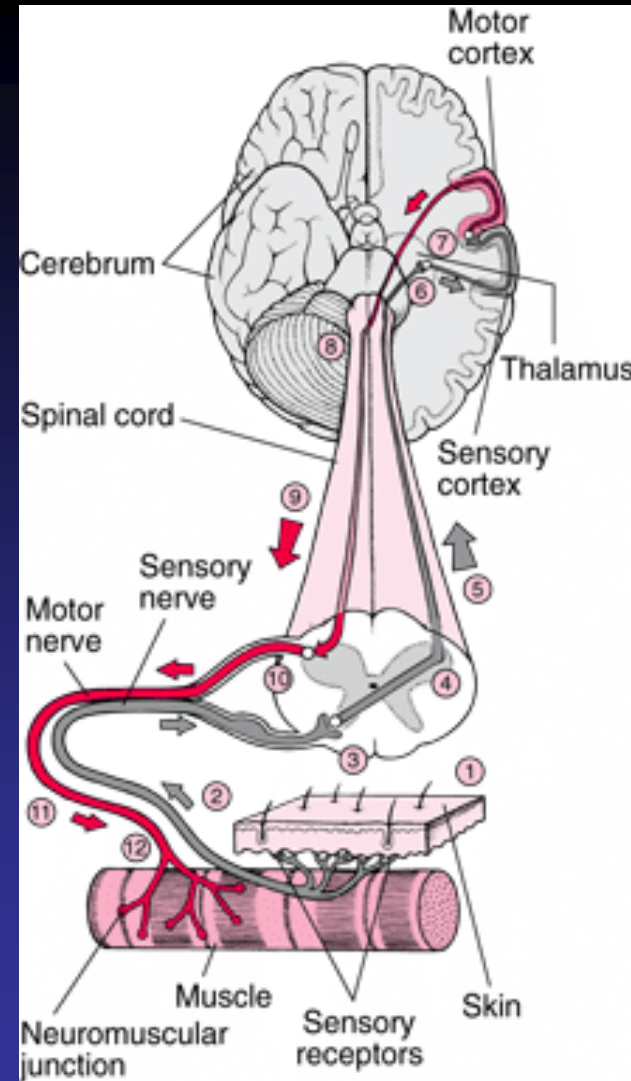
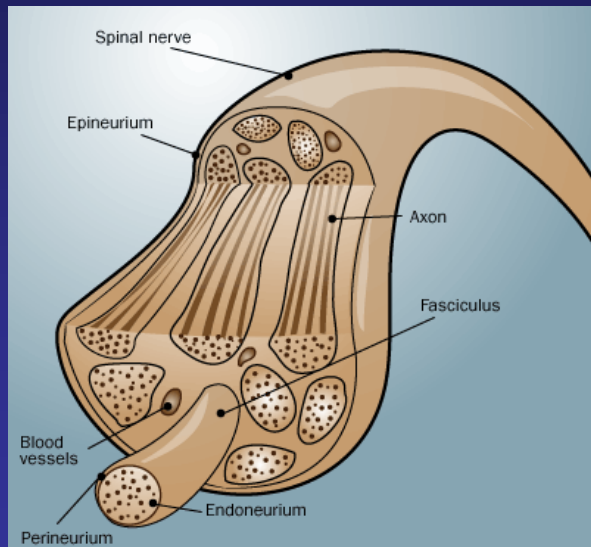
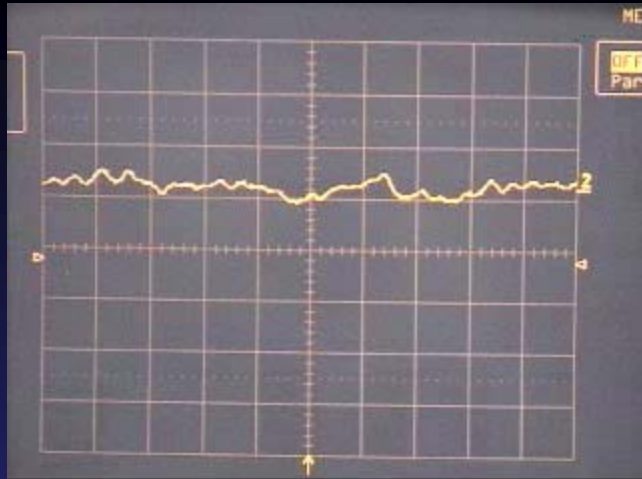
Google “Neural Prosthesis Program”

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Outline

- Signaling in the Nervous System
 - Signal sources of cortex and peripheral nerve
- Clinically Useful Neural Interfaces
- Cortical Recording Arrays
- Peripheral Nerve Interfaces
- Challenges and Opportunities for Microsystems in New Neural Interfaces

Signaling in the Nervous System



Control signal sources at the level of motor cortex and peripheral nerve

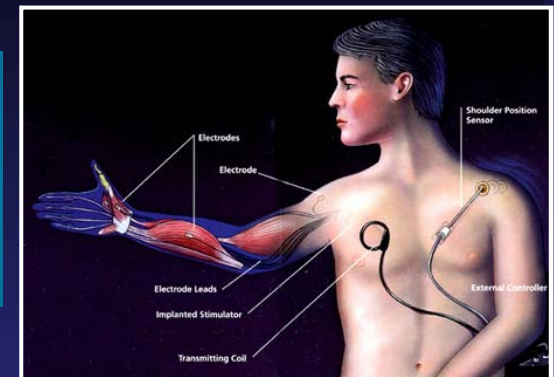
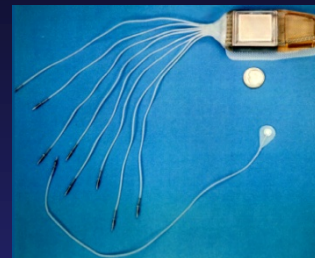
Clinically-Relevant Neural Interfaces

Neural interfaces have already provided substantial benefits to individuals.



Cochlear Ltd. Nucleus® 24 cochlear implant system

Cochlear Prosthesis bypasses damaged hair cells in the auditory system by direct electrical stimulation of the auditory nerve. 60,000 world-wide

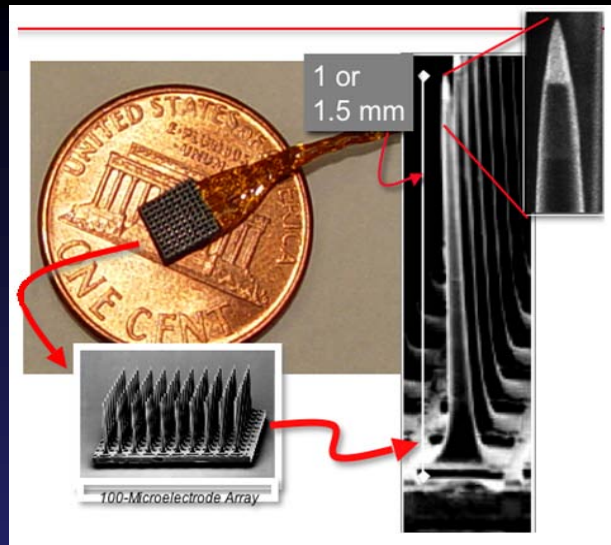


Case Western Reserve University, Cleveland, OH

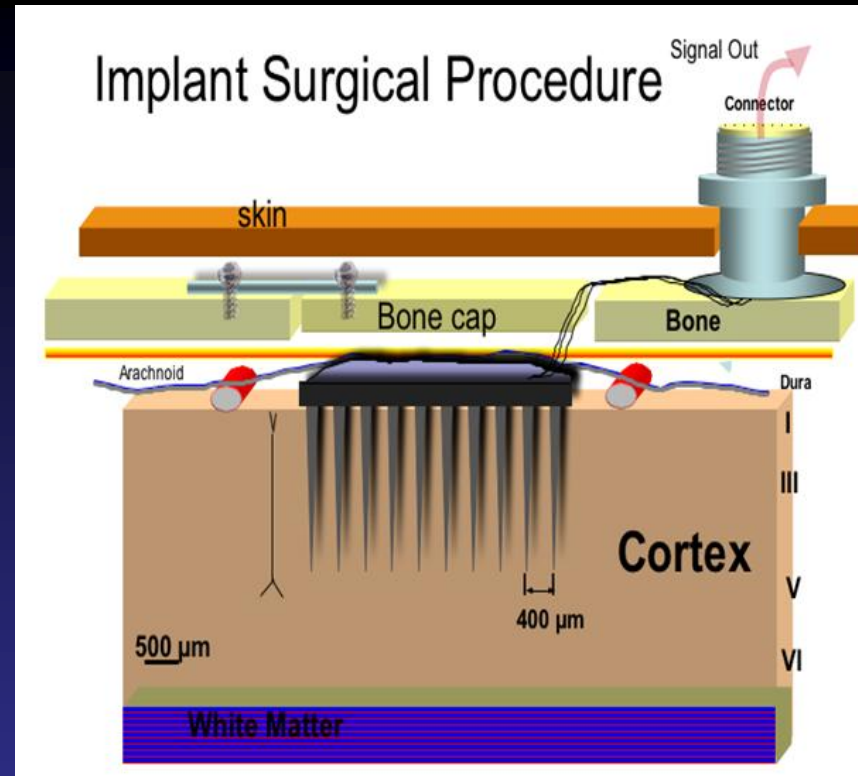
Functional Electrical Stimulation has been used to restore motor function in paralyzed individuals. e.g., Upper- and lower-extremity, bladder.

- Neural Interfaces for restoring neurological function via electrical stimulation
- Cortical recording arrays and the peripheral nerve interfaces?

Cortical Recording Arrays



Design inspired by biology?



Critical Issue – tethering forces

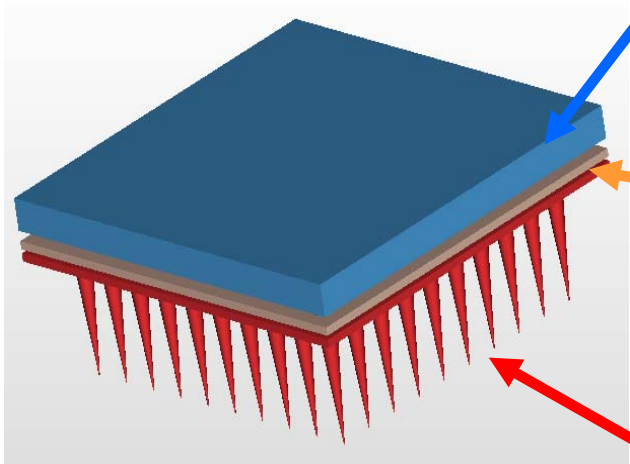
- Pedestal connector, wireless system
- Cable flexibility and scalability

Cortical Array Microsystems

F. Solzbacher, University of Utah – K. Shenoy, Stanford

Performance Specifications

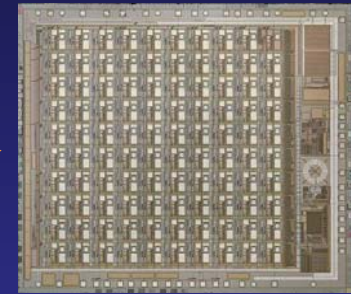
100 recording sites, integrated spike detection, 6 months capability



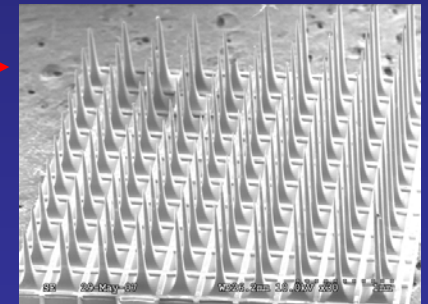
Thin film fabricated
gold-on-polyimide
coil for wireless
power/data transfer



Integrated
amplifiers, signal
processing & RF
telemetry electronics
VLSI ASIC



Microelectrode array

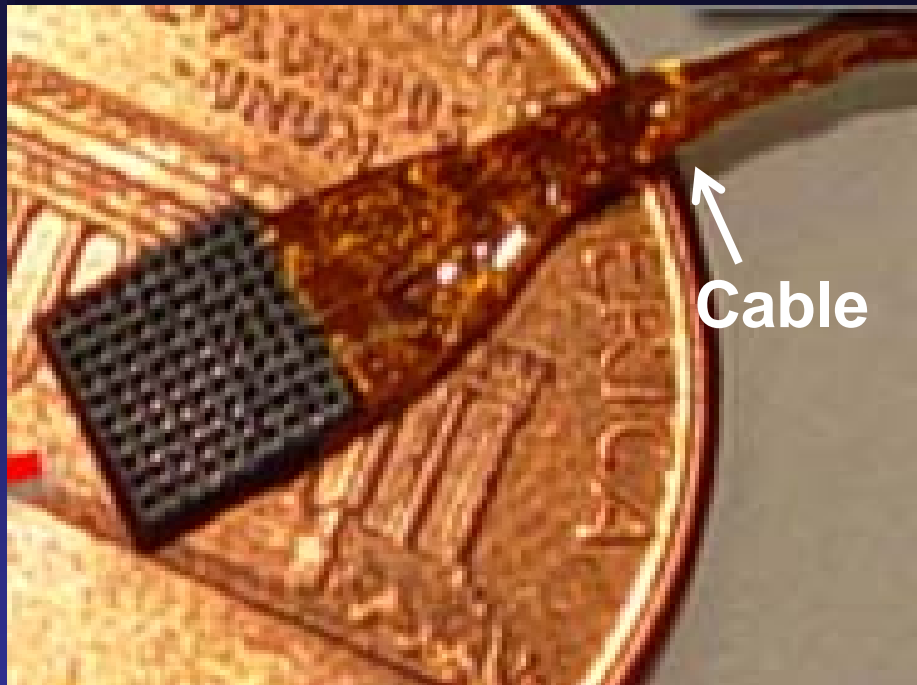


- Demonstrated wireless operation of implanted chip in non-human primates.
- Research platform for freely behaving non-human primates; pre-clinical technology

Cortical Array Microsystems

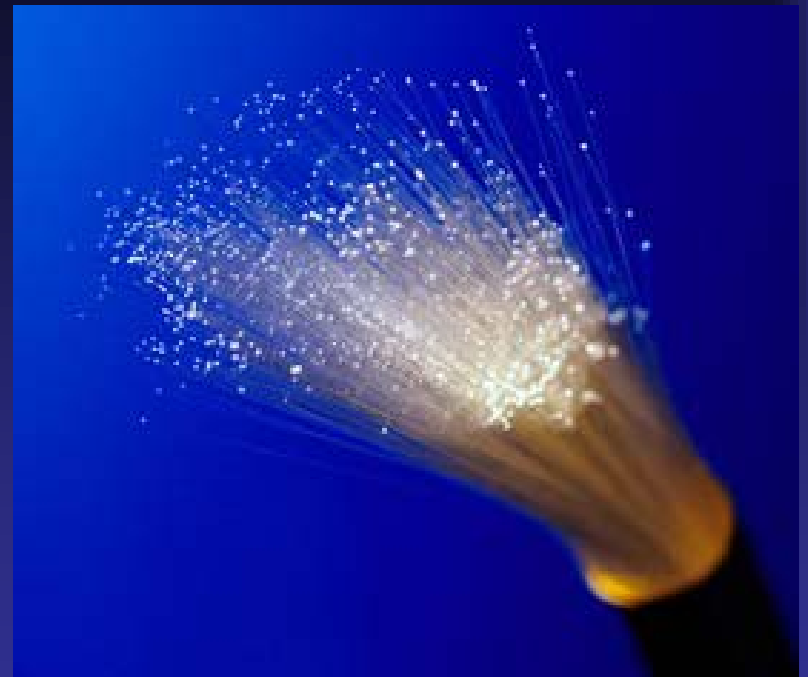
Critical issue:

Cable flexibility & scalability – limit to how many leads you can pack.



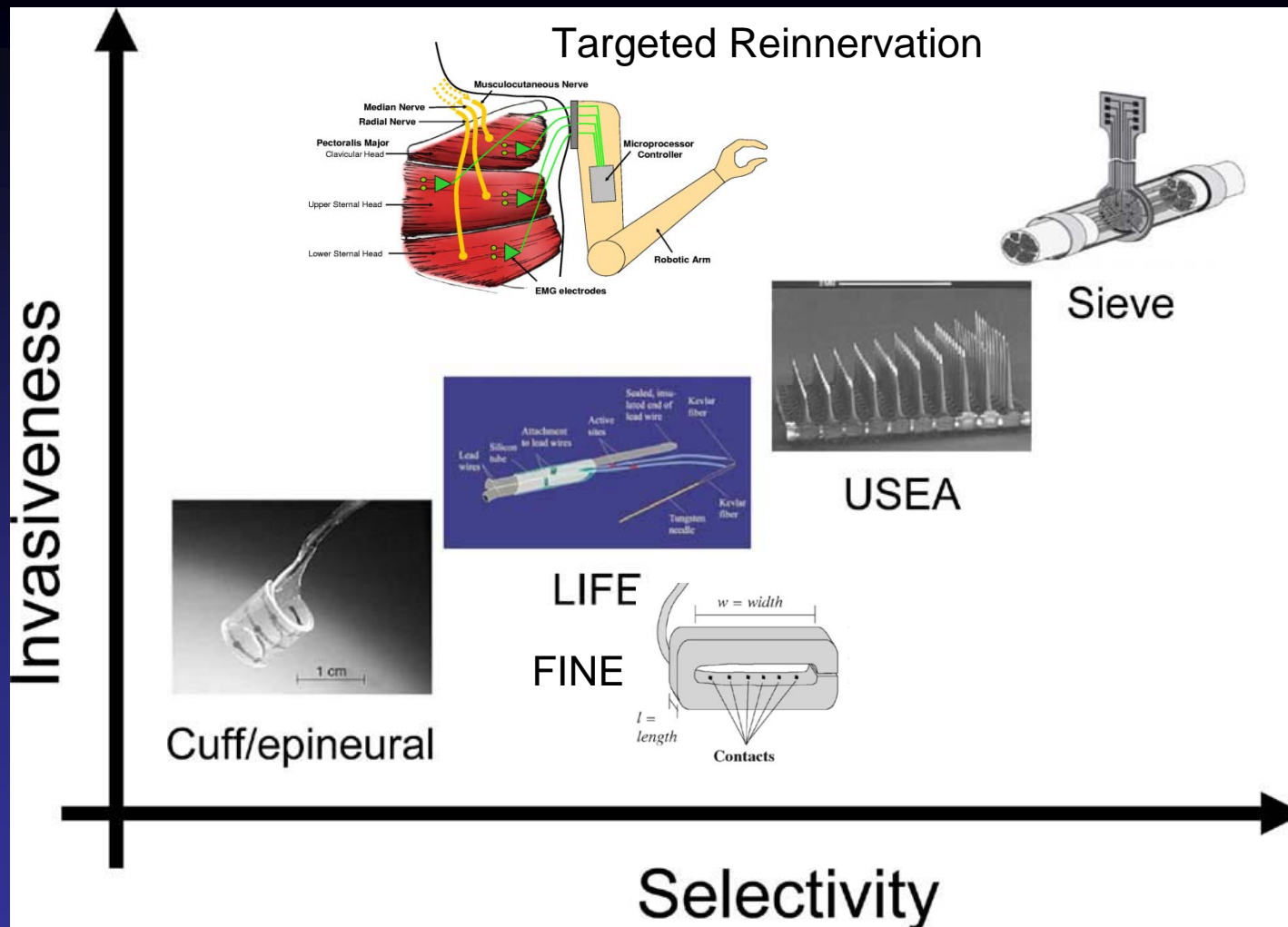
Possible Approach:

Collapse cable into a single biocompatible optical fiber.



Challenge: develop and demonstrate low power multi-channel data acquisition chip to multiplex data onto one optical fiber

Peripheral Nerve Interfaces



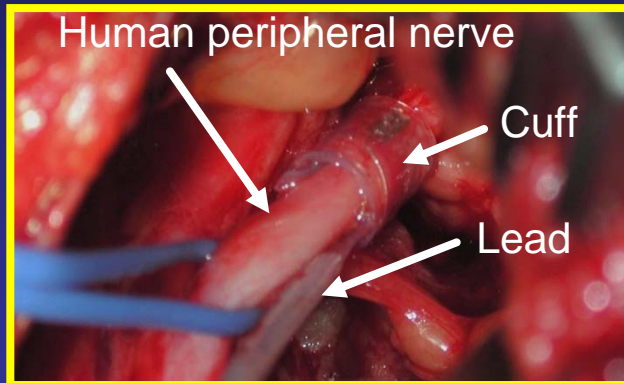
Adapted from IEEE Trans Neural Syst Rehab Engin 16: 453-472 (2008)

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Peripheral Nerve Microsystems

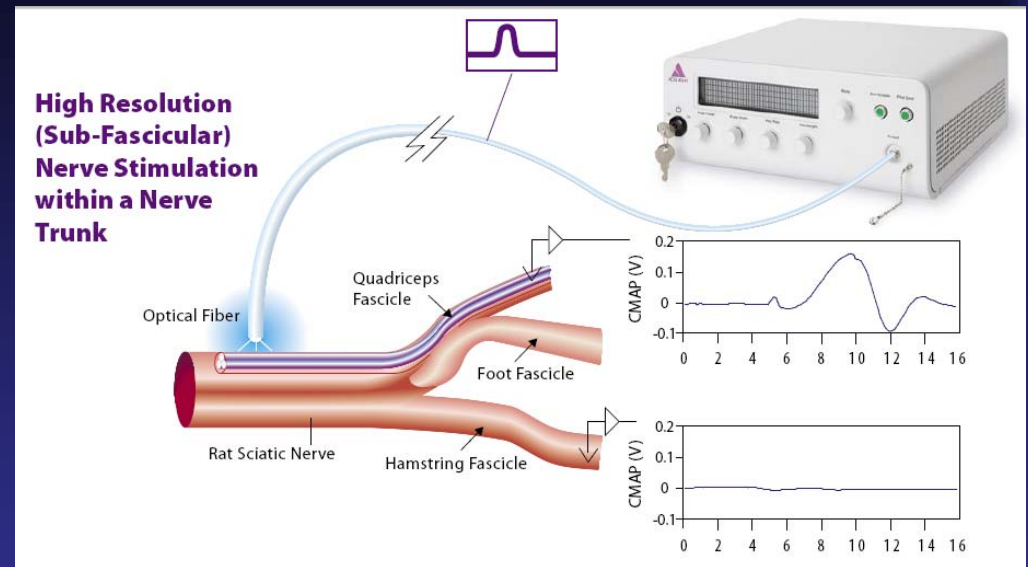
Critical issue:

Lack of spatial selectivity with electrical stimulation of cuff electrodes



Possible Approach:

Optically-based stimulation – use spatial selectivity of light



Infrared pulses, $\lambda=4 \mu\text{m}$, $<1\text{J}/\text{cm}^2$

From *Optics Lett.* 30: 504-506 (2005) – Vanderbilt & Aculight

Challenge: implement flexible cuff electrodes that incorporate multiple light sources

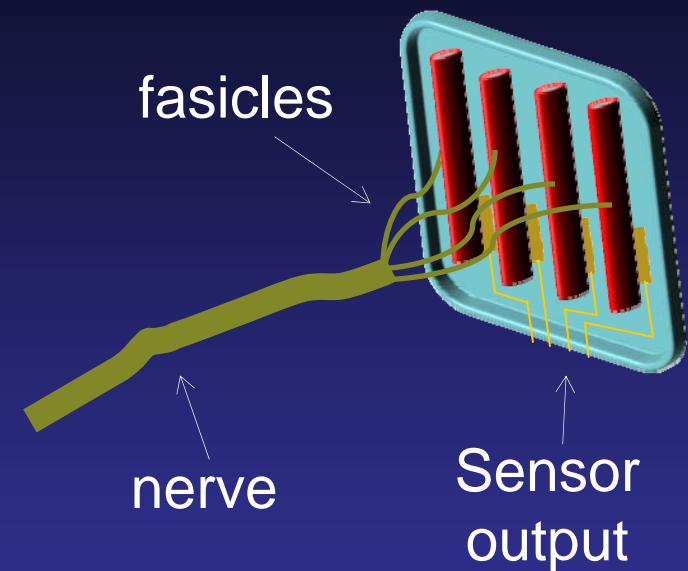
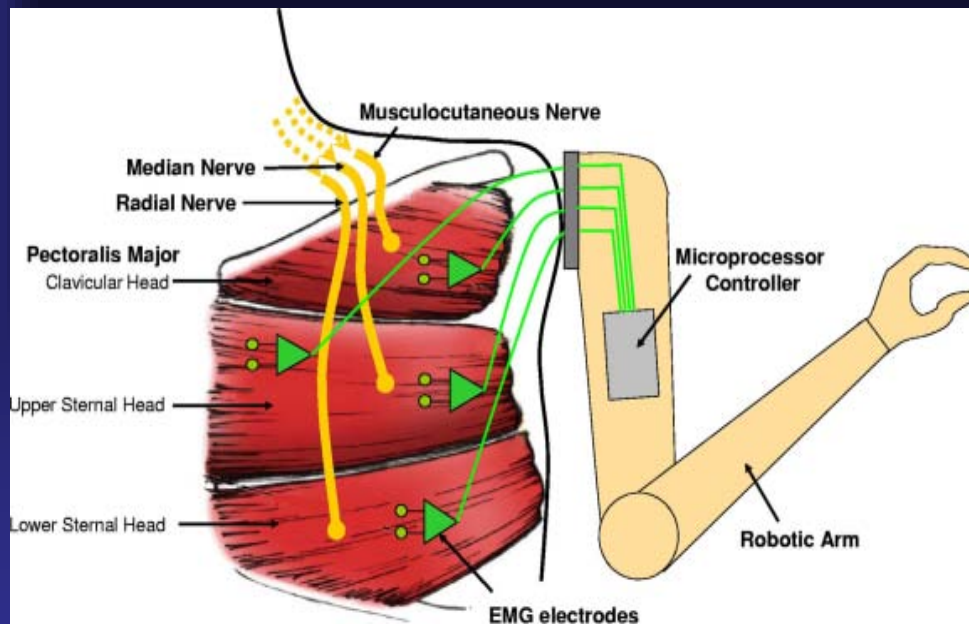
Peripheral Nerve Microsystems

Critical issue:

Selectivity of targeted reinnervation limited to donor muscle constraints

Possible Approach:

Microscale reinnervation; device integrated muscle fibers



From *J Neurophysiol* .98:2974-2982 (2007)

Challenge: develop microelectrode/microactuator integrated 3D structures that maintain myofiber integrity and nerve viability

Summary

- Neural Interfaces - applications
- Opportunities and challenges for integrating microsystems in neural interfaces:
 - Optical technologies
 - Microscale targeted reinnervation
- Emergence of computational neuroscience systems biology – eventually will result in predictive models of biological that facilitate the design of interactive microsystems.

Thank you

MICROSYSTEMS TECHNOLOGY OFFICE

MTO SYMPOSIUM

The logo for the Microsystems Technology Office (MTO) Symposium. It features the letters 'MTO' in a large, bold, metallic font. A globe with the word 'DARPA' on it is integrated into the 'O'. Circuit traces extend from the 'M' and 'O'. Below 'MTO' is the word 'SYMPOSIUM' in a smaller, white, sans-serif font. The entire logo is set against a dark background with a reflection effect below it.

BUILDING THE FUTURE
FROM THE INSIDE OUT

The background of the poster is a collage of various technological and infrastructure elements. On the left, there's a large satellite dish and a solar panel array. In the center, a complex antenna structure is visible. On the right, there's a detailed view of a ship's deck with various equipment. The entire background is overlaid with a blue grid pattern and a network of lines and nodes, suggesting a global or interconnected system.

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